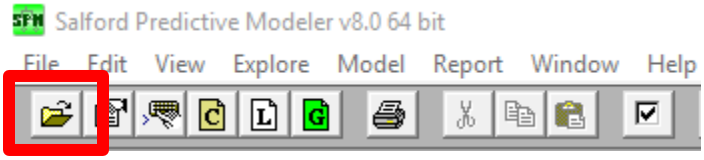
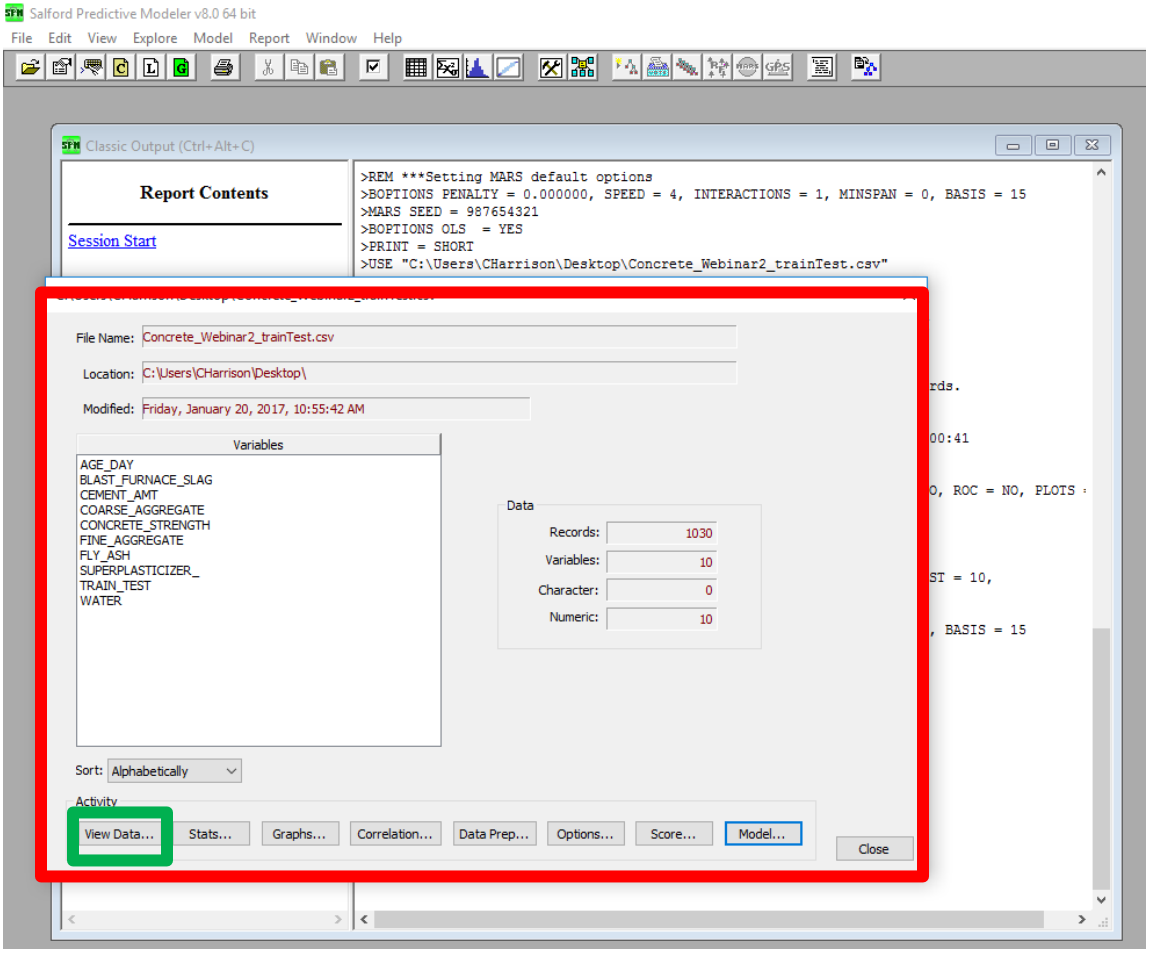
Step-by-Step Guide to CART® Software

Read in the data to SPM

1. Click the Open Data shortcut button

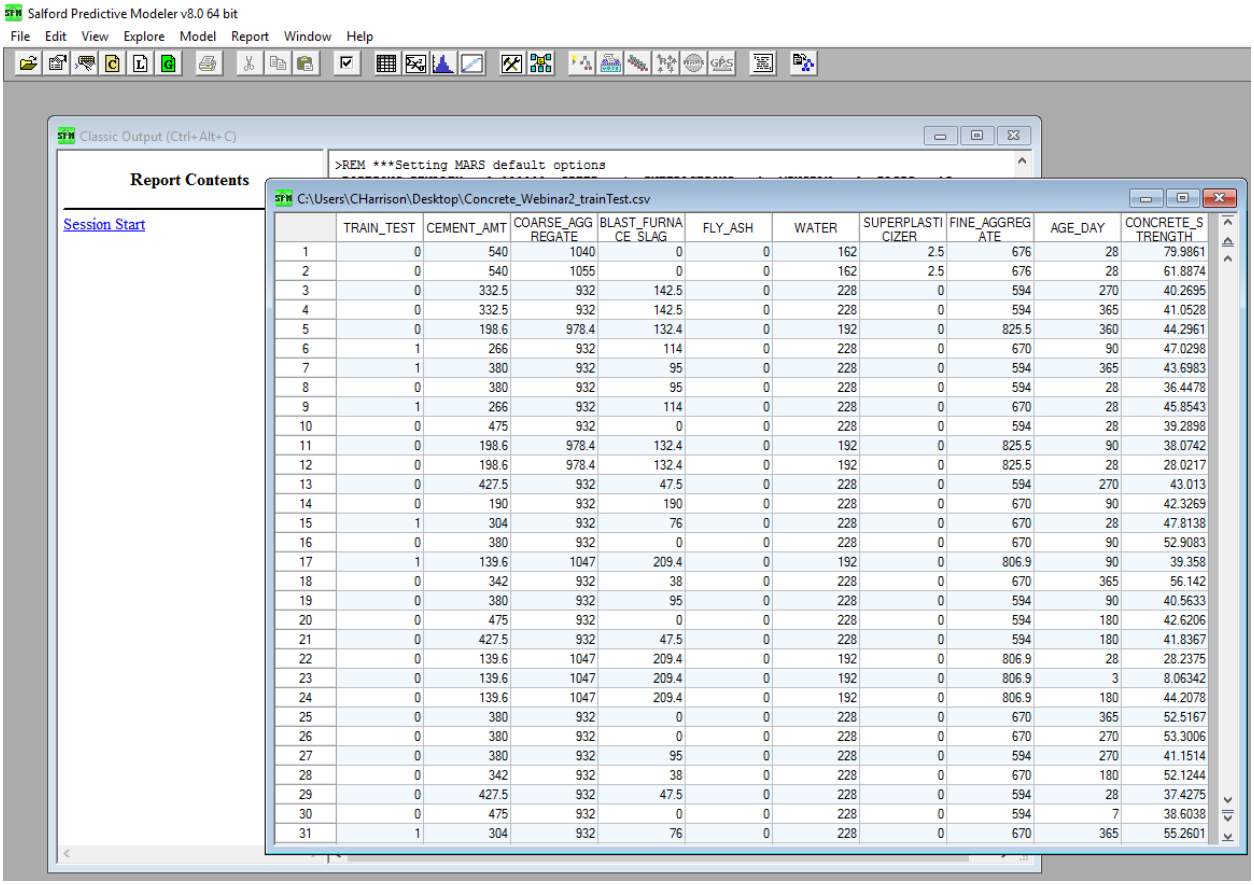


2. Double click on the data file name. After doing so you will see the **Activity Window:**



The Activity Window can be used to View the dataset, compute summary statistics, construct histograms, compute correlations and other measures of similarity, perform basic data preparation tasks (if desired), predict new observations, and build a model.

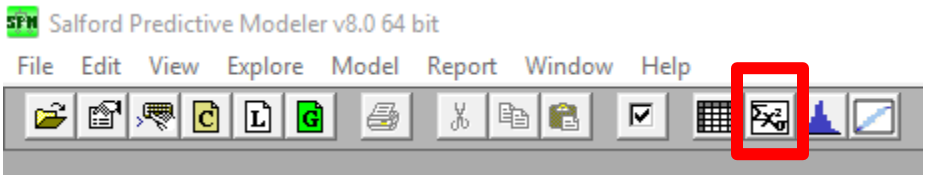
3. Click “View Data” (green rectangle above). The result will be the following:



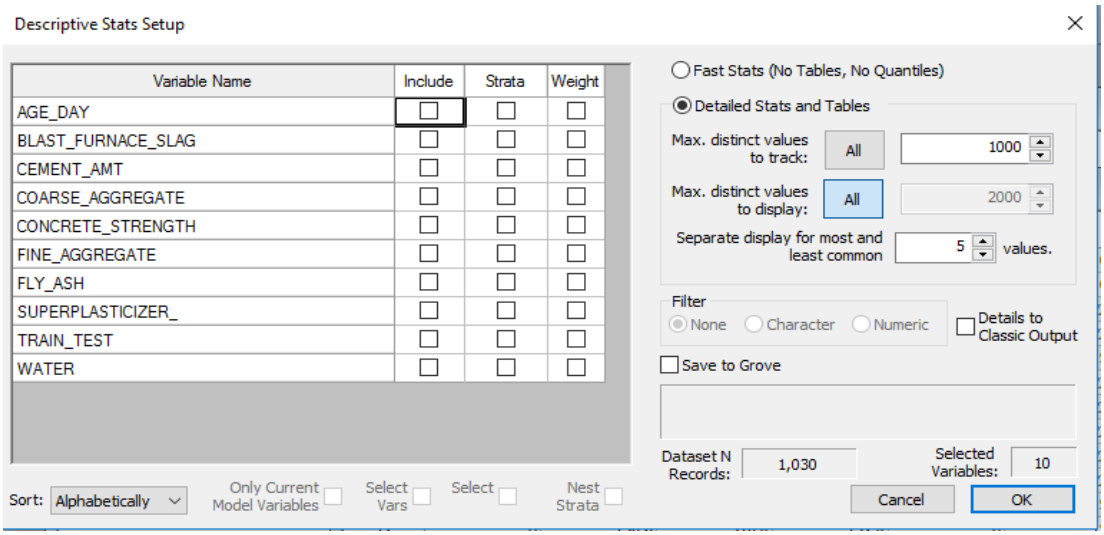
	TRAIN_TEST	CEMENT_AMT	COARSE_AGGREGATE	BLAST_FURNACE_SLAG	FLY_ASH	WATER	SUPERPLASTICIZER	FINE_AGGREGATE	AGE_DAY	CONCRETE_STRENGTH
1	0	540	1040	0	0	162	2.5	676	28	79.9861
2	0	540	1055	0	0	162	2.5	676	28	61.8874
3	0	332.5	932	142.5	0	228	0	594	270	40.2695
4	0	332.5	932	142.5	0	228	0	594	365	41.0528
5	0	198.6	978.4	132.4	0	192	0	825.5	360	44.2961
6	1	266	932	114	0	228	0	670	90	47.0298
7	1	380	932	95	0	228	0	594	365	43.6983
8	0	380	932	95	0	228	0	594	28	36.4478
9	1	266	932	114	0	228	0	670	28	45.8543
10	0	475	932	0	0	228	0	594	28	39.2898
11	0	198.6	978.4	132.4	0	192	0	825.5	90	38.0742
12	0	198.6	978.4	132.4	0	192	0	825.5	28	28.0217
13	0	427.5	932	47.5	0	228	0	594	270	43.013
14	0	190	932	190	0	228	0	670	90	42.3269
15	1	304	932	76	0	228	0	670	28	47.8138
16	0	380	932	0	0	228	0	670	90	52.9083
17	1	139.6	1047	209.4	0	192	0	806.9	90	39.358
18	0	342	932	38	0	228	0	670	365	56.142
19	0	380	932	95	0	228	0	594	90	40.5633
20	0	475	932	0	0	228	0	594	180	42.6206
21	0	427.5	932	47.5	0	228	0	594	180	41.8367
22	0	139.6	1047	209.4	0	192	0	806.9	28	28.2375
23	0	139.6	1047	209.4	0	192	0	806.9	3	8.06342
24	0	139.6	1047	209.4	0	192	0	806.9	180	44.2078
25	0	380	932	0	0	228	0	670	365	52.5167
26	0	380	932	0	0	228	0	670	270	53.3006
27	0	380	932	95	0	228	0	594	270	41.1514
28	0	342	932	38	0	228	0	670	180	52.1244
29	0	427.5	932	47.5	0	228	0	594	28	37.4275
30	0	475	932	0	0	228	0	594	7	38.6038
31	1	304	932	76	0	228	0	670	365	55.2601

Note: the variable TRAIN_TEST is used to distinguish between the LEARN data (i.e. the data used to build the tree; also called the “Training Data”) and the TEST data (i.e. the data used to validate the model; also called “Validation Data”)

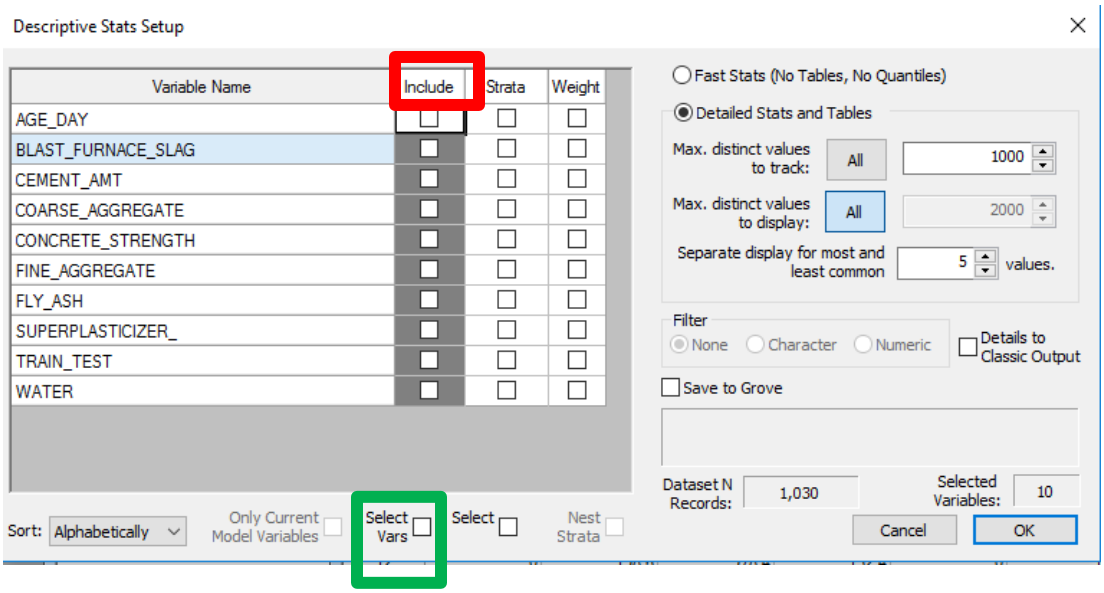
4. I want to see if any variables are categorical, so I am going to compute summary statistics and look at the number of distinct levels for each variable. Note that any variables with character data (Example: “Male” or “Female”) are automatically read in as categorical variables but variables that have values 0 or 1 (Example: 0 is female and 1 is male) are read in as numeric. Click the Summary Statistics shortcut button below (red rectangle):



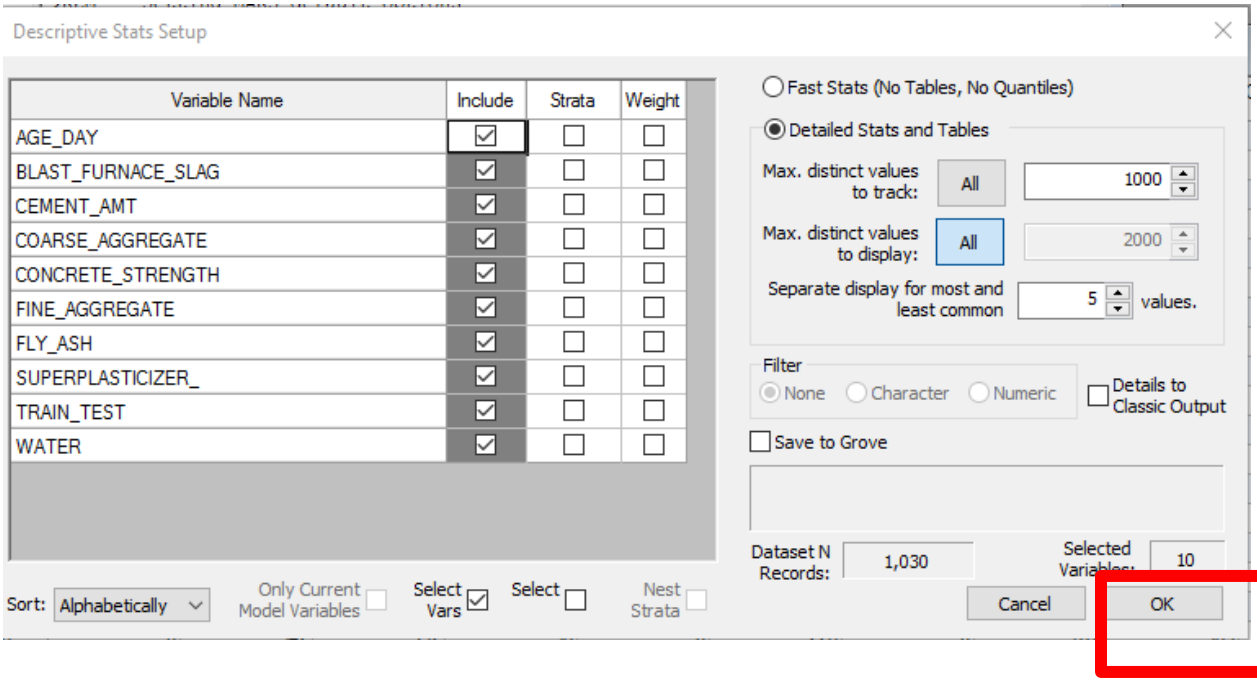
The result will be the following:



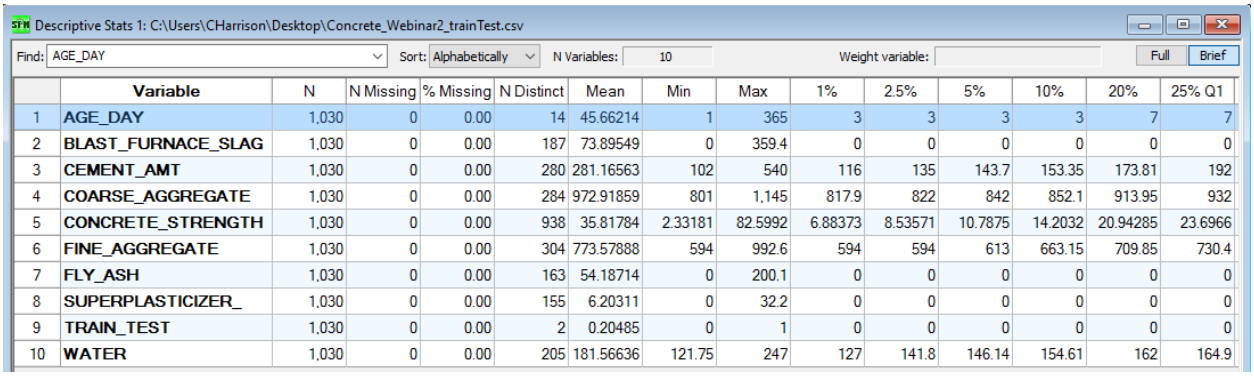
Click the “Include” label to highlight all variables and click “Select Vars” to select all variables



The result will be the following. Now click “OK”



The result will be the following. Look at the N Distinct column. This column tells you how many unique values there are for each variable. Note that all variables have many values and are numeric so we can just treat them as continuous (TRAIN_TEST is NOT a predictor and is used to distinguish between the LEARN and TEST DATA).

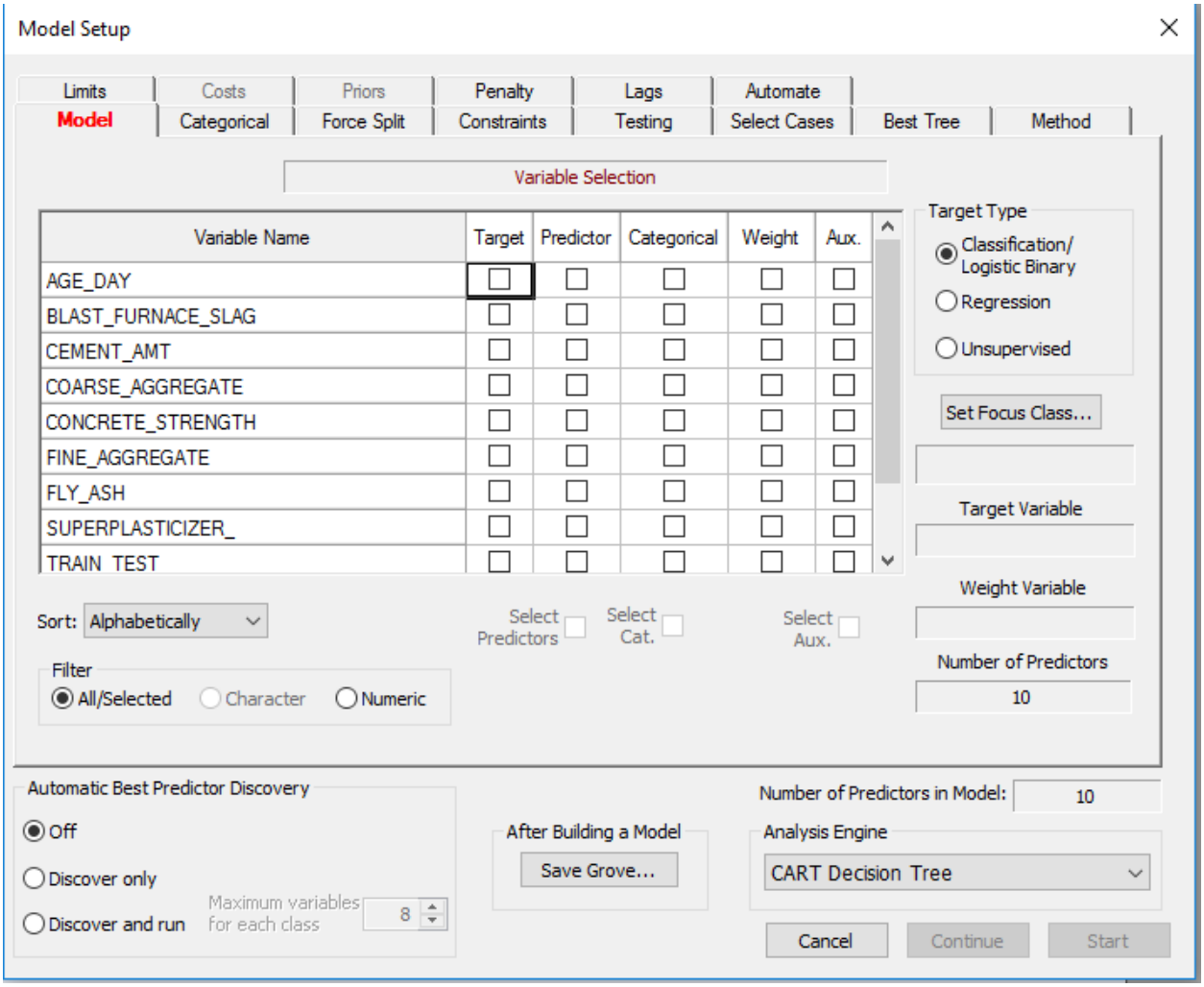


	Variable	N	N Missing	% Missing	N Distinct	Mean	Min	Max	1%	2.5%	5%	10%	20%	25% Q1
1	AGE_DAY	1,030	0	0.00	14	45.66214	1	365	3	3	3	3	7	7
2	BLAST_FURNACE_SLAG	1,030	0	0.00	187	73.89549	0	359.4	0	0	0	0	0	0
3	CEMENT_AMT	1,030	0	0.00	280	281.16563	102	540	116	135	143.7	153.35	173.81	192
4	COARSE_AGGREGATE	1,030	0	0.00	284	972.91859	801	1,145	817.9	822	842	852.1	913.95	932
5	CONCRETE_STRENGTH	1,030	0	0.00	938	35.81784	2.33181	82.5992	6.88373	8.53571	10.7875	14.2032	20.94285	23.6966
6	FINE_AGGREGATE	1,030	0	0.00	304	773.57888	594	992.6	594	594	613	663.15	709.85	730.4
7	FLY_ASH	1,030	0	0.00	163	54.18714	0	200.1	0	0	0	0	0	0
8	SUPERPLASTICIZER_	1,030	0	0.00	155	6.20311	0	32.2	0	0	0	0	0	0
9	TRAIN_TEST	1,030	0	0.00	2	0.20485	0	1	0	0	0	0	0	0
10	WATER	1,030	0	0.00	205	181.56636	121.75	247	127	141.8	146.14	154.61	162	164.9

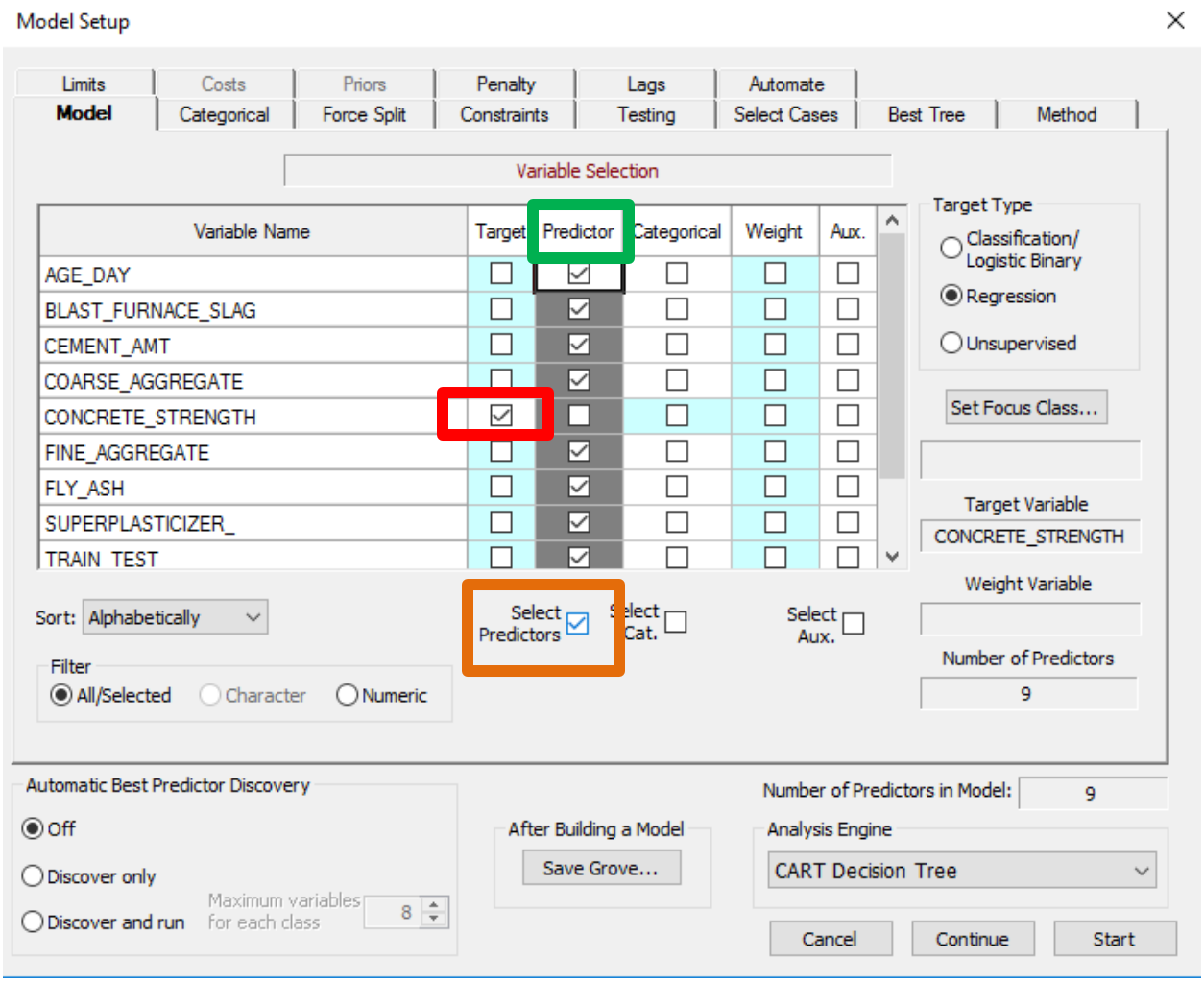
Build a CART Model

1. Click the model setup shortcut button

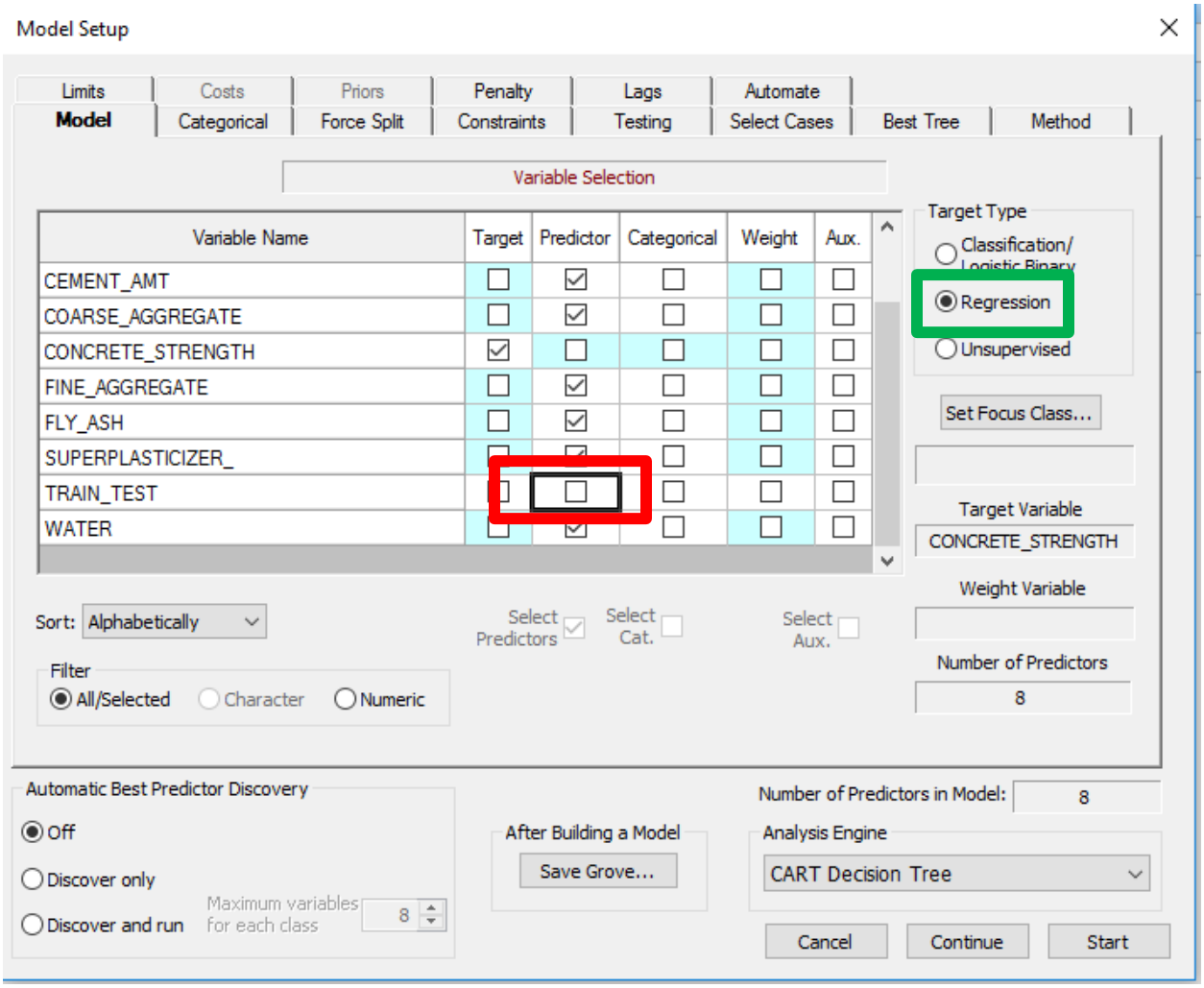
The result will be the following:



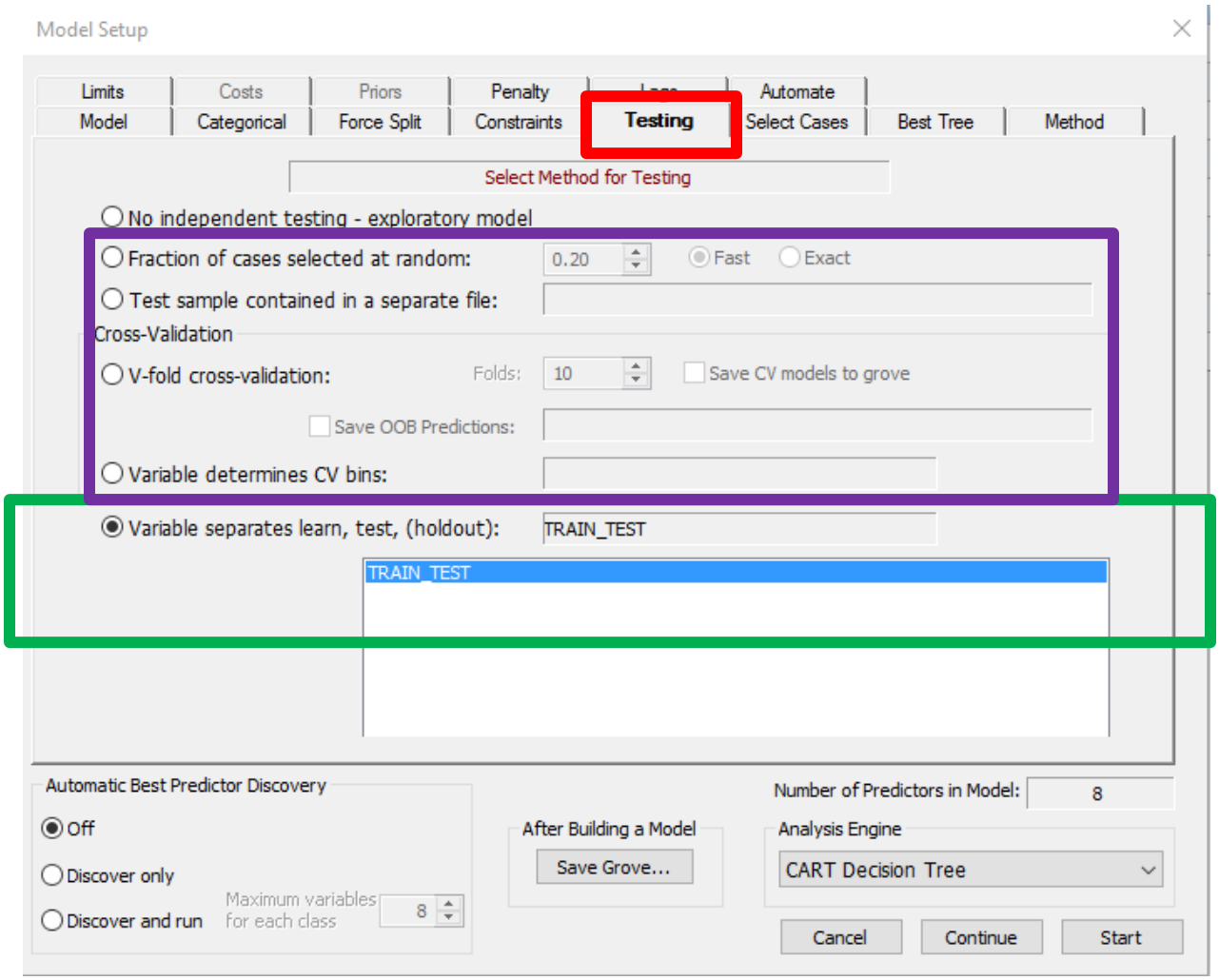
2. Setup the variables: Click the box in the Target column for the variable “CONCRETE_STRENGTH” (red rectangle below) and set the rest of the variables as predictors by clicking the “Predictor” label (green rectangle below) to highlight the column and then click “Select Predictors” checkbox (orange rectangle below). The result will be the following:



3. Uncheck the checkbox in the “Predictor” column for the variable TRAIN_TEST because it is not a predictor variable (red rectangle below). Set the “Target Type” to be “Regression” (green rectangle below). The final result will be the following:

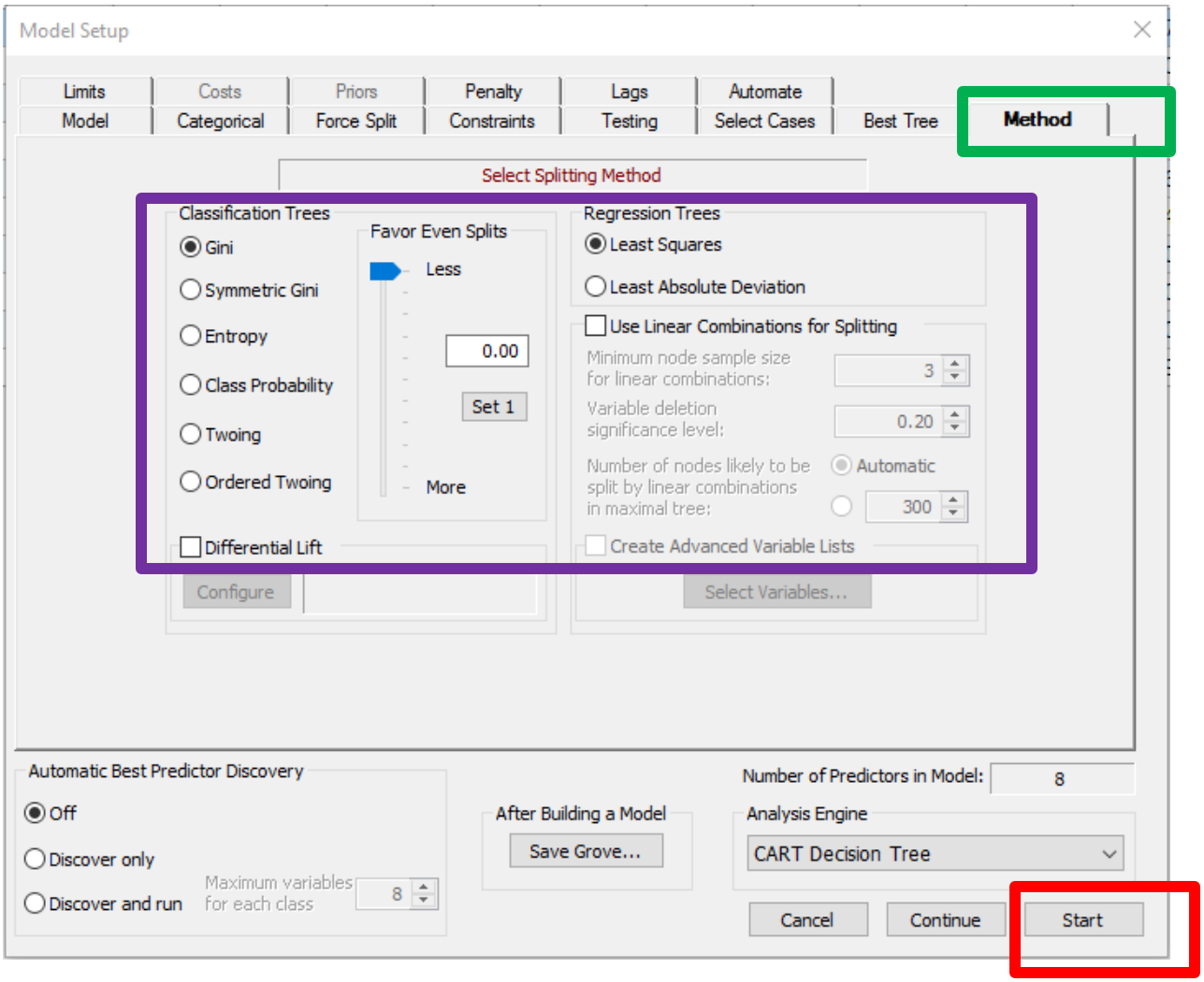


4. Click the “Testing” Tab (red rectangle below) and click the radio button next to “Variable separates learn, test, (holdout):” **and** then click “TRAIN_TEST” (green rectangle below):



This setting ensures that the LEARN and TEST data are the same for CART and Random Forest so we can compare their performance on the TEST data (we really don’t care about the LEARN performance). Now if you want to use a test sample but you aren’t worried about comparisons then select either cross validation (for smaller and medium sized datasets), “Fraction of cases selected at random”, or “Test sample contained in a separate file”(purple rectangle above)

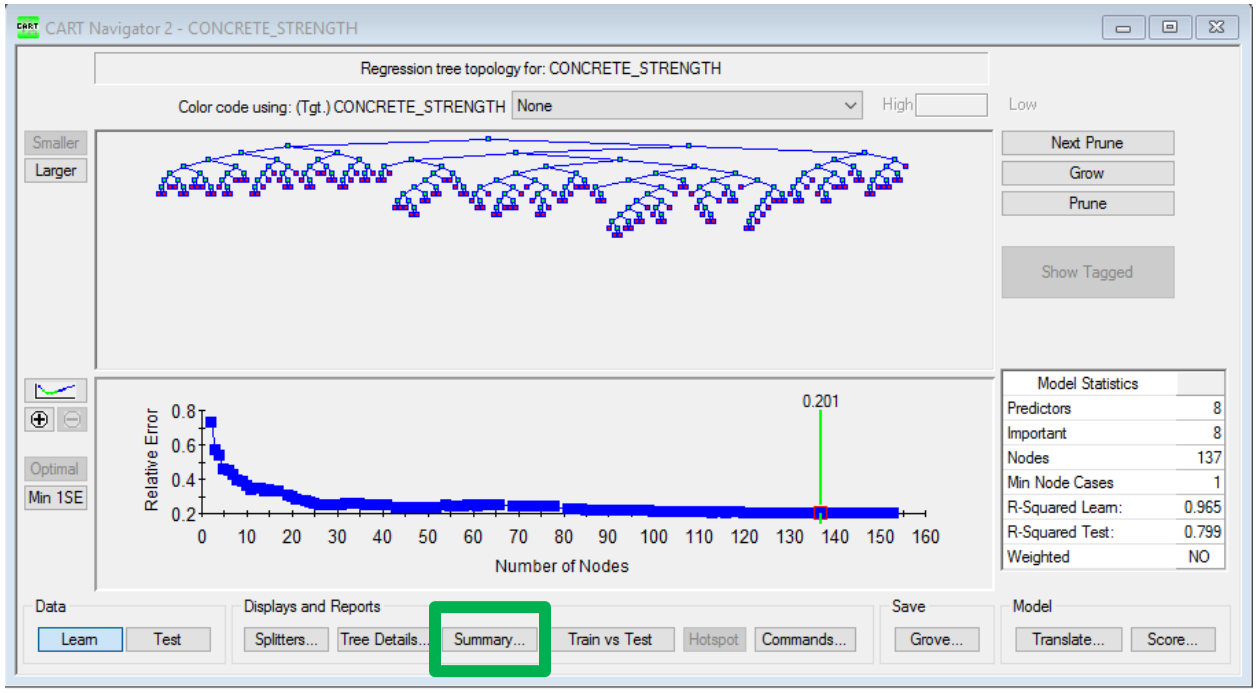
5. Click the “Method” tab



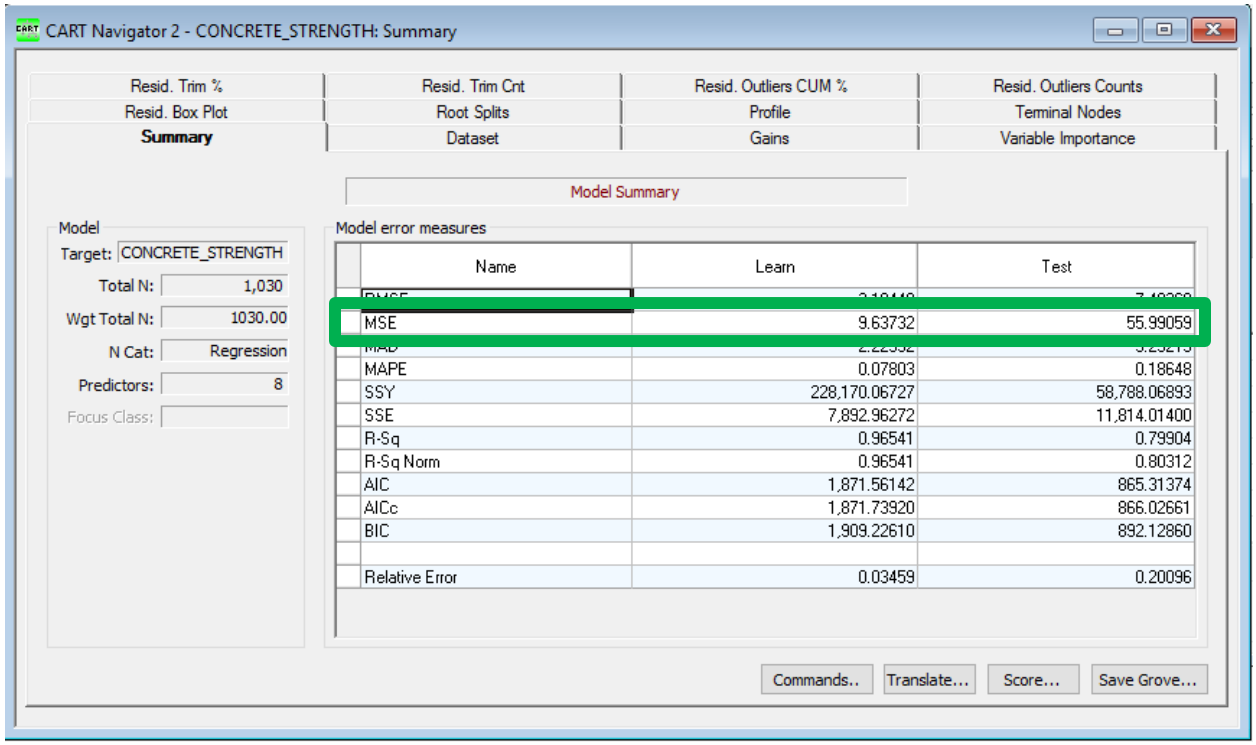
Note: the method for regression trees is set to “Least Squares” by default. If you want to change the method for either regression or classification trees then you can do so in this tab. I just want to show you this, so just leave the default settings for now.

Click “Start” to build the CART model (red rectangle above).

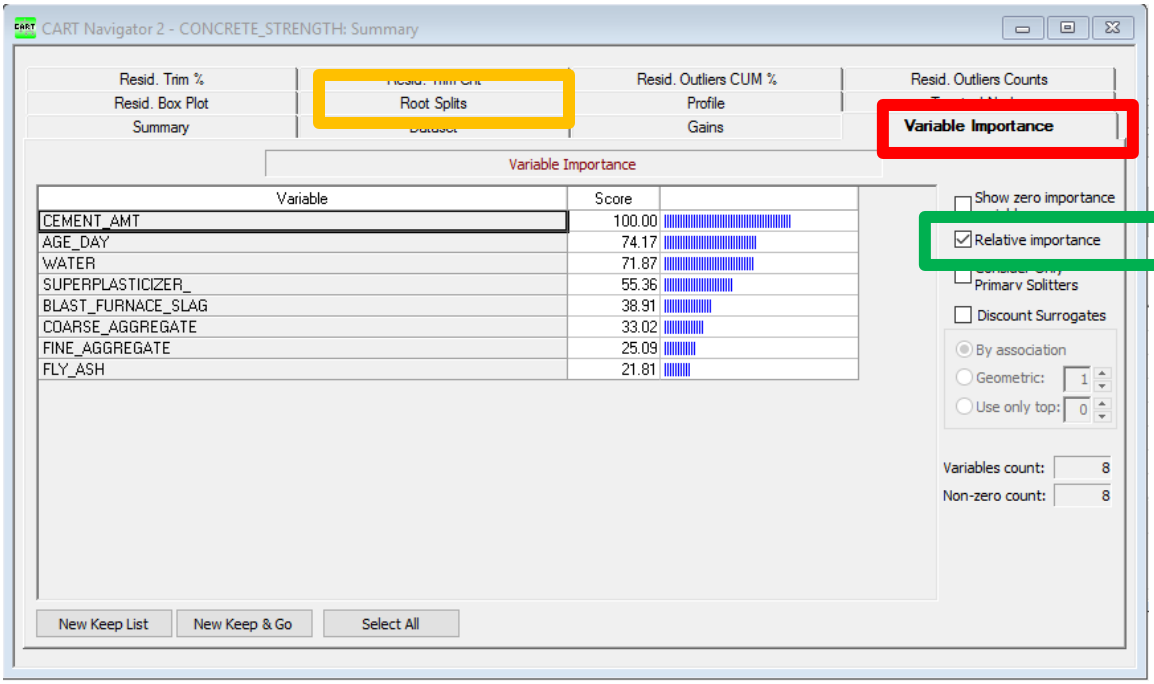
6. Here is the optimal CART tree. To view the summary statistics for this model click “Summary…” (green rectangle below)



Here are the results. Note the value for the MSE on the test data is 55.99:

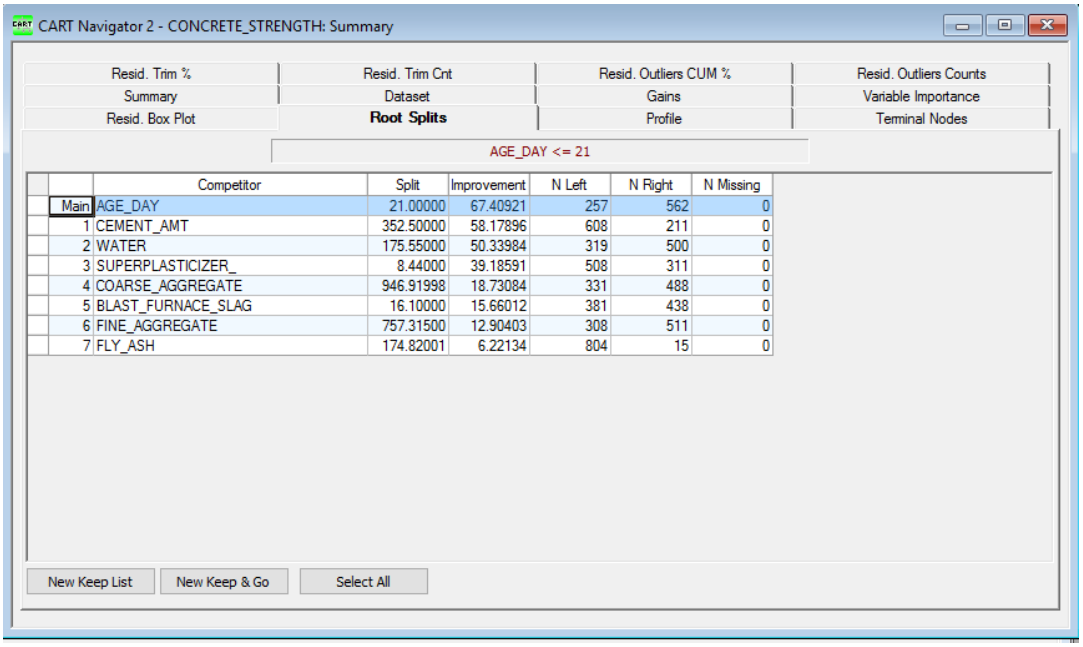


7. To view the “Variable Importance” click the variable importance tab (red rectangle below)



Note: currently Relative Importance is currently checked so each raw importance score has been divided by the maximum score which results in the most important variable having a value of 100% and so on. To view the raw importance score simply uncheck the checkbox next to “Relative Importance” (green rectangle above)

8. To view the improvement scores in the root node (i.e. the node at the top of the tree prior to any splitting) then click the “Root Splits” tab (orange rectangle **above**).



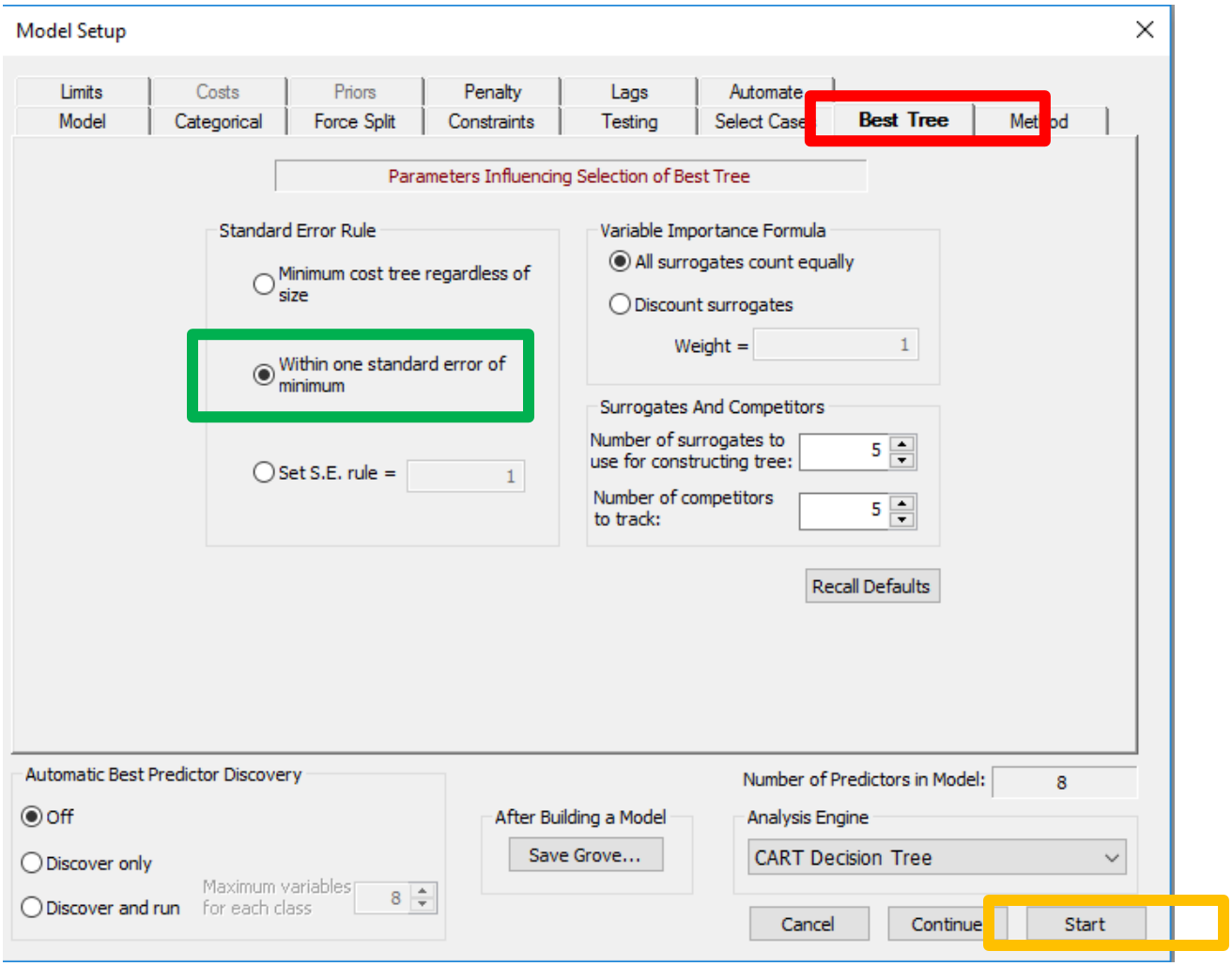
Note: AGE_DAY and CEMENT_AMT both have high improvement scores which may indicate (not always) that they are highly correlated.

Viewing detailed summary statistics for the 1 Standard Error CART Tree

9. To view detailed results (i.e. MSE, SSE, etc.) for the minimum 1 standard error tree do the following:

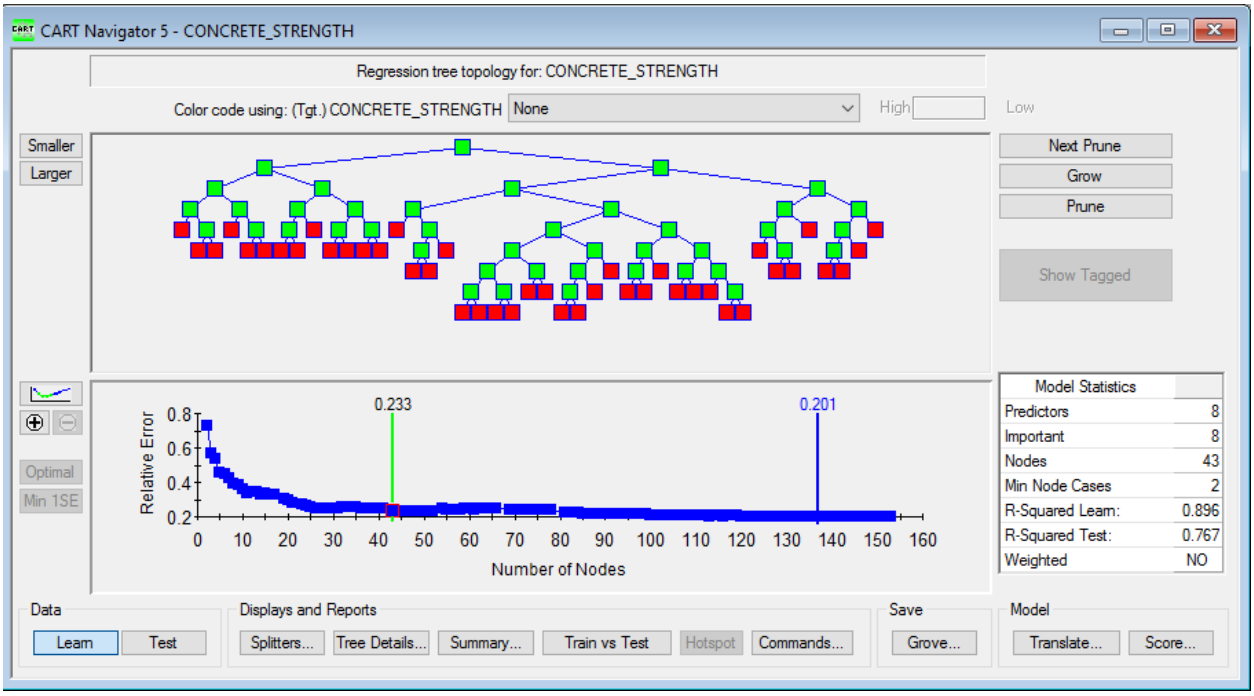
a) Setup the model as described previously

b) Go the "Best Tree" tab (red rectangle below) and click the radio button next to "Within one standard error minimum" (green rectangle below). Now click "Start" (orange rectangle below)

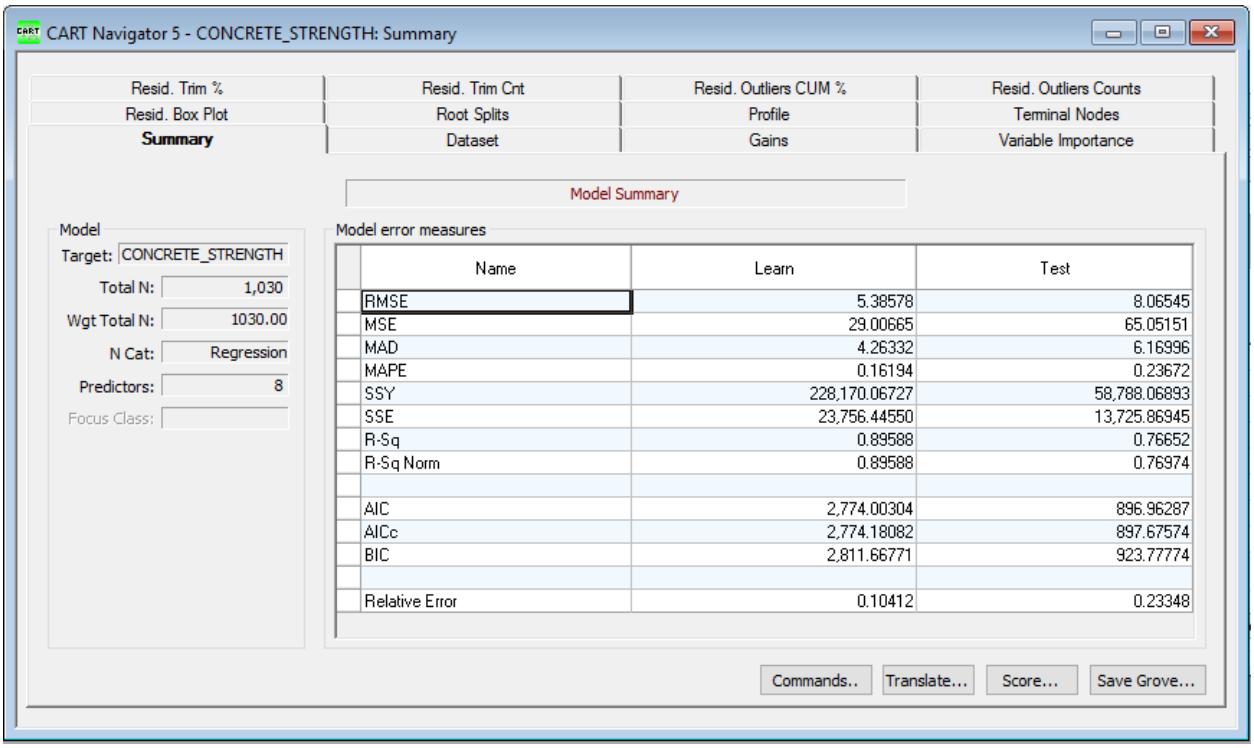


The tree that you see will be the 1 standard error tree.

10. Click “Summary”

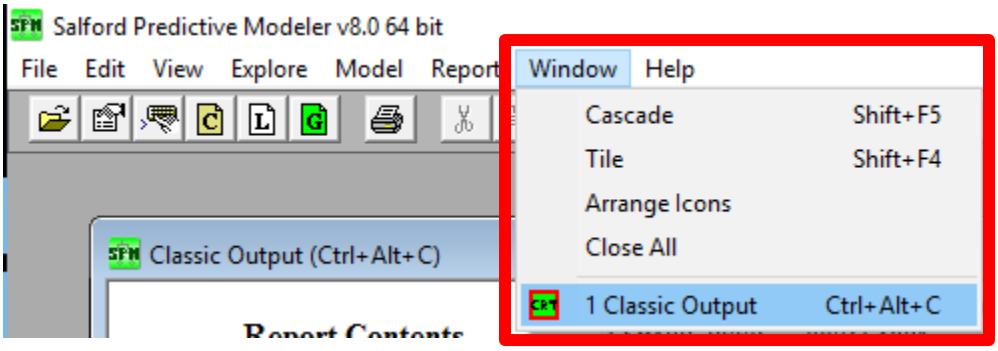


Here are the results. Note that you can now see detailed summary statistics for this tree:

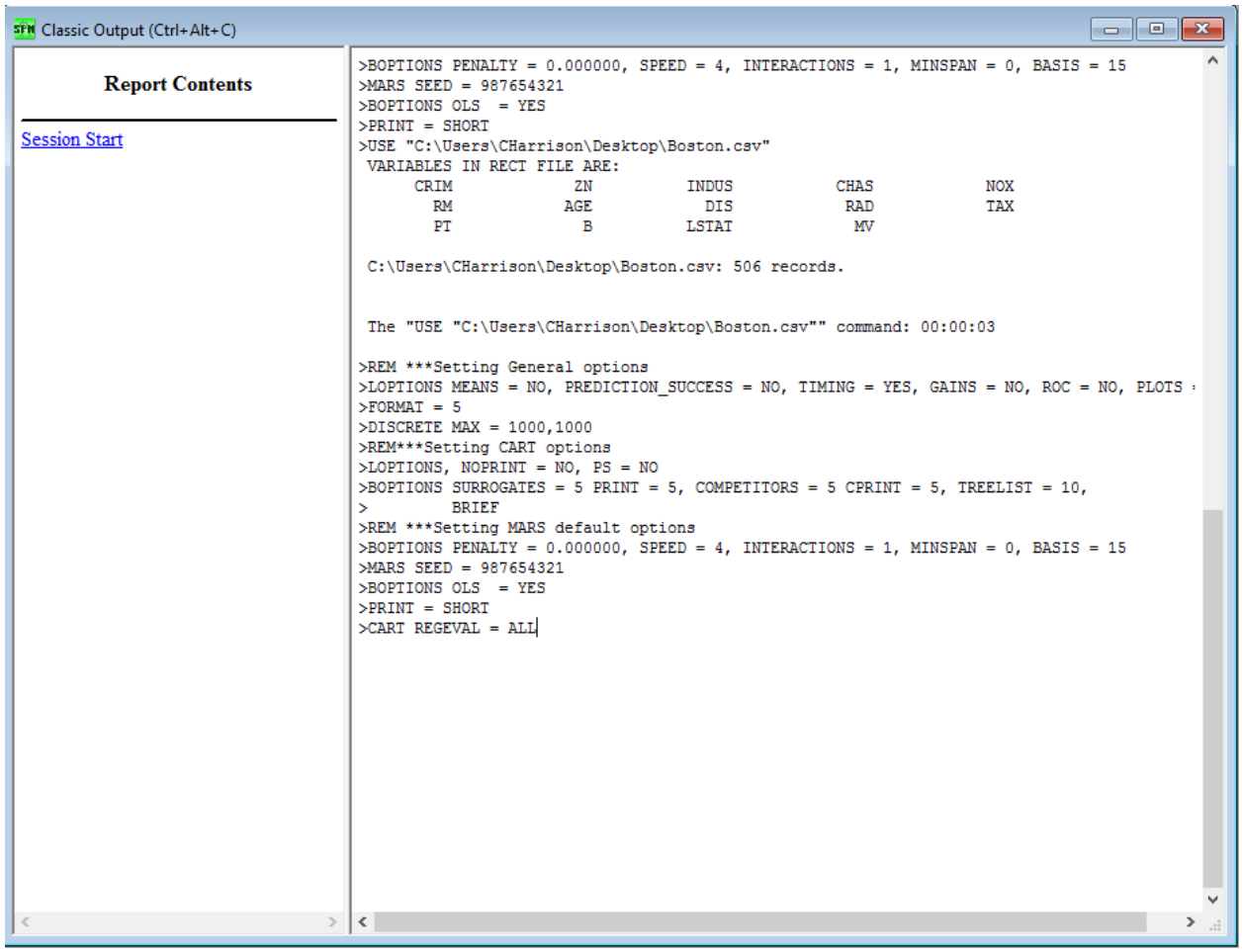


Viewing detailed summary statistics for all trees in the pruning sequence

1. Go to the Classic Output Window by clicking Window > Classic Output



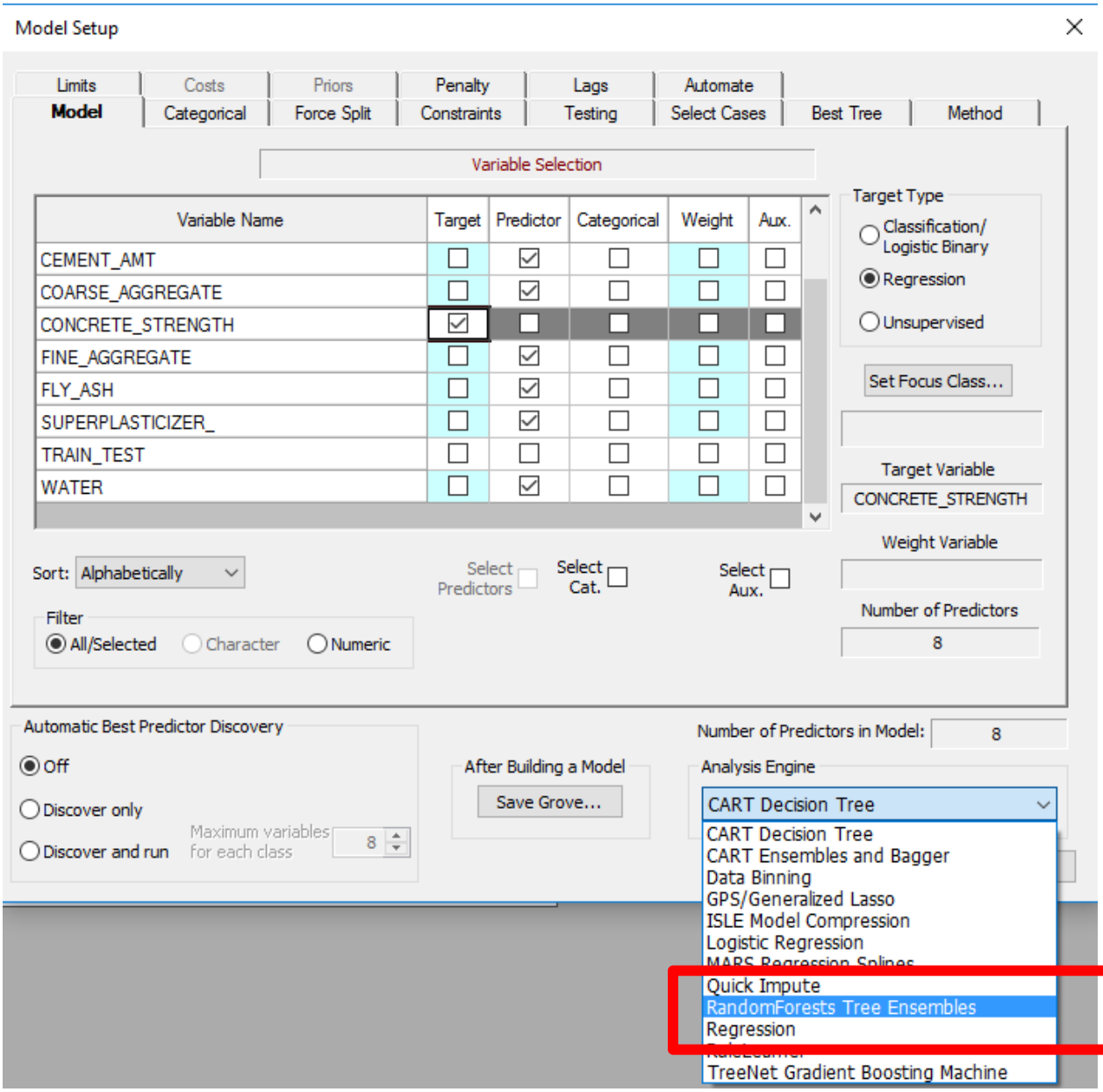
You will see the following window. Now type `CART REGEVAL = ALL`
Press Enter to submit the command. Now build a CART model and now you can see summary statistics for each tree in the pruning sequence. **Note: this will result in a longer computing time because now we are computing summary statistics for dozens of trees.**



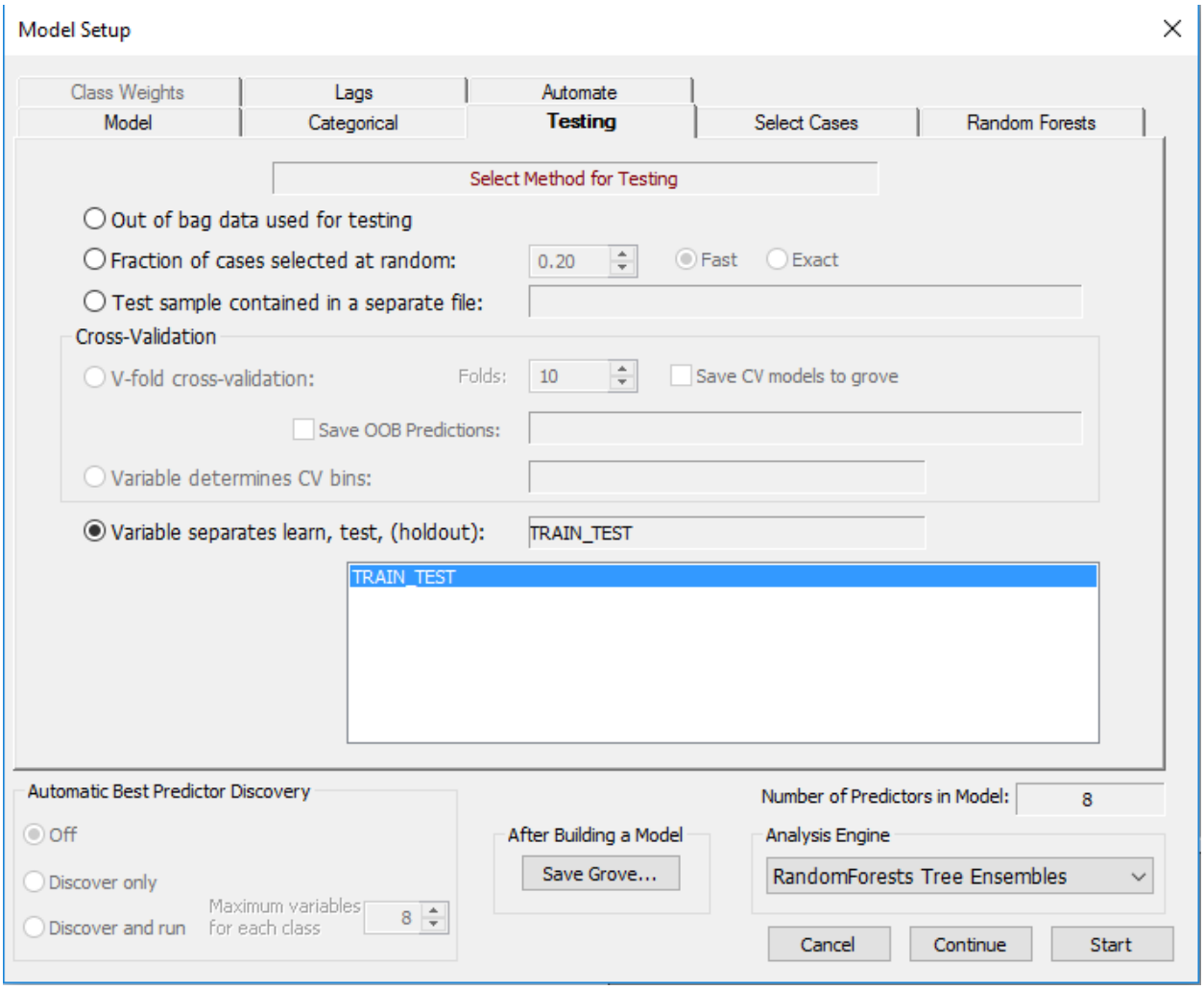
Building a Random Forest Model

1. Click the model setup shortcut button

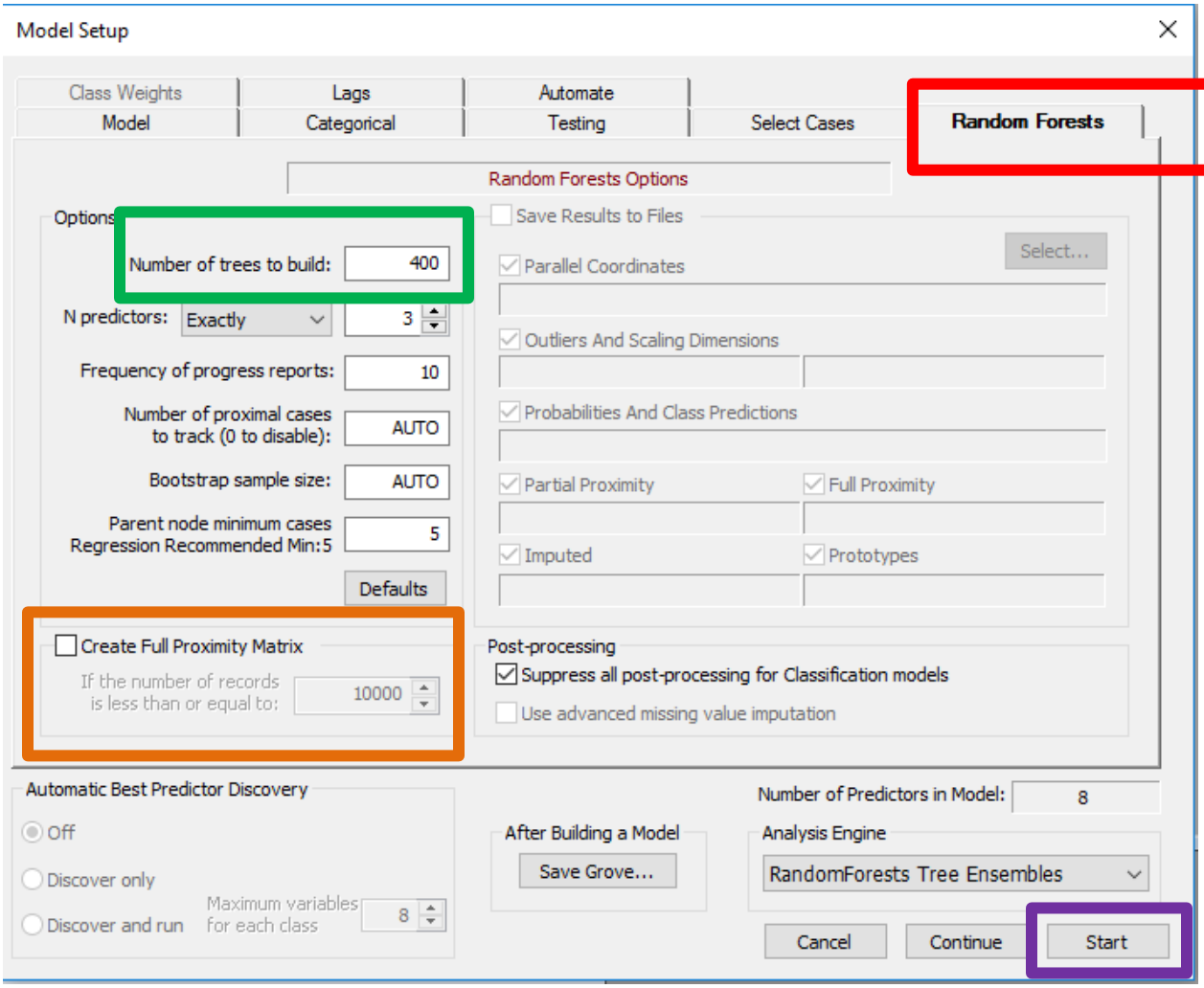
2. Set the analysis engine to RandomForests Tree Ensembles (Red Rectangle below)



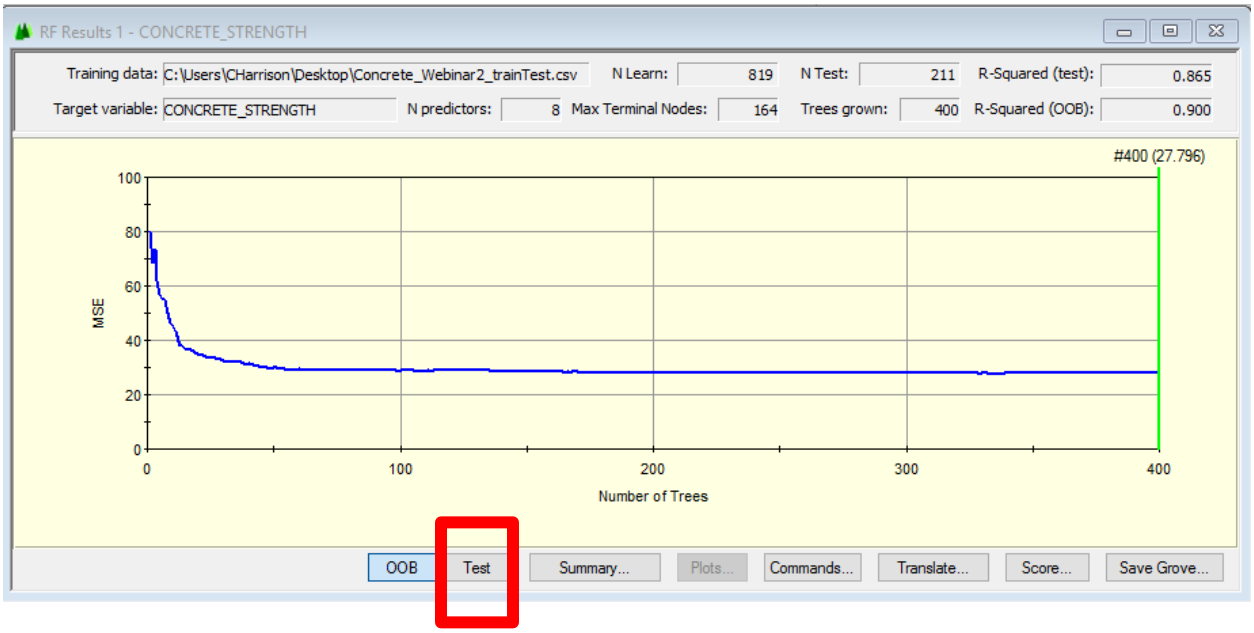
3. Since we want to compare the Random Forest with CART tree and the linear regression model we will use the same LEARN and TEST partition as was used for those models. Click the "Testing" Tab (red rectangle below) and click the radio button next to "Variable separates learn, test, (holdout):" **and** then click "TRAIN_TEST" (green rectangle below):



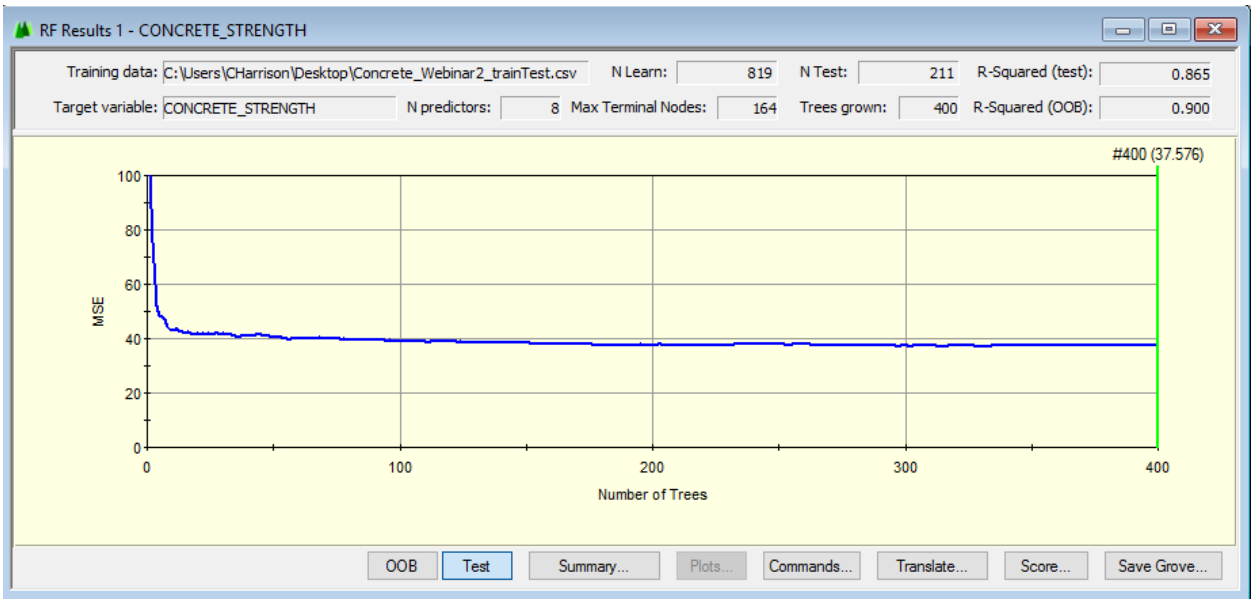
4. Click the Random Forests tab (red rectangle below). Set the number of trees to 400 (green rectangle below) and uncheck the checkbox next to “Create Full Proximity Matrix” (orange rectangle below). Click “Start” (purple rectangle below) to build a Random Forest.



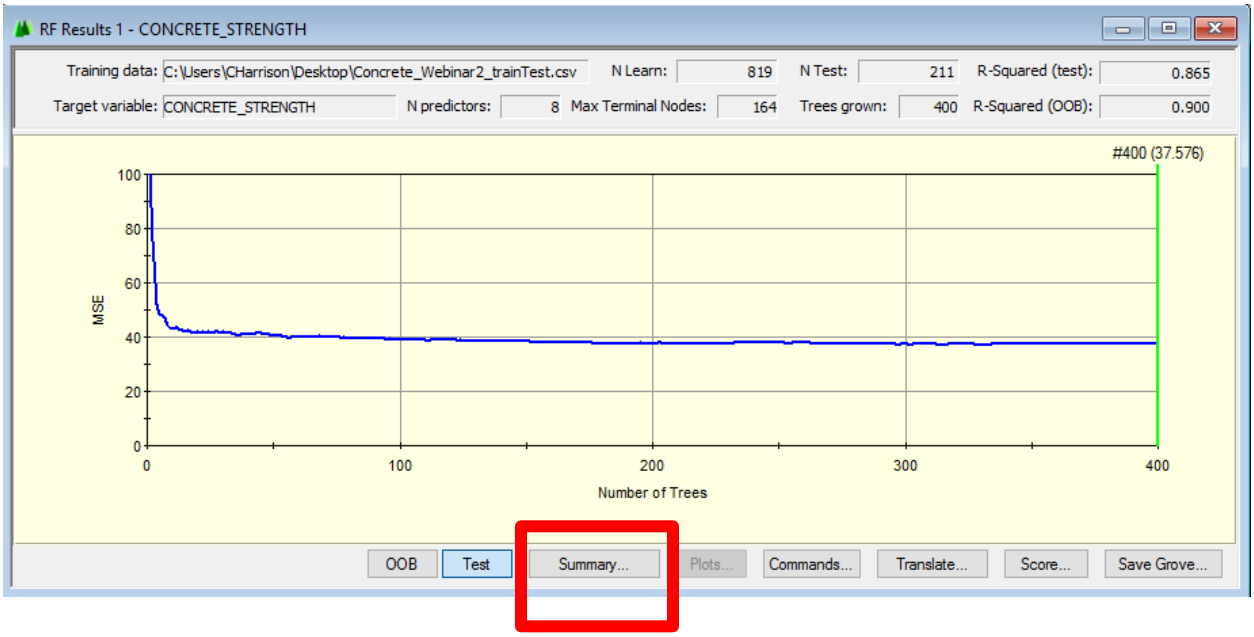
Note: the first error measurement that you will see is the “OOB” error (OOB = “**O**ut **O**f **B**ag”), but since we want to compare our RandomForest model directly with the CART and linear regression model we need to click “Test” to view the error for the test data that we defined earlier in the Testing tab. Click “Test” (red rectangle below)



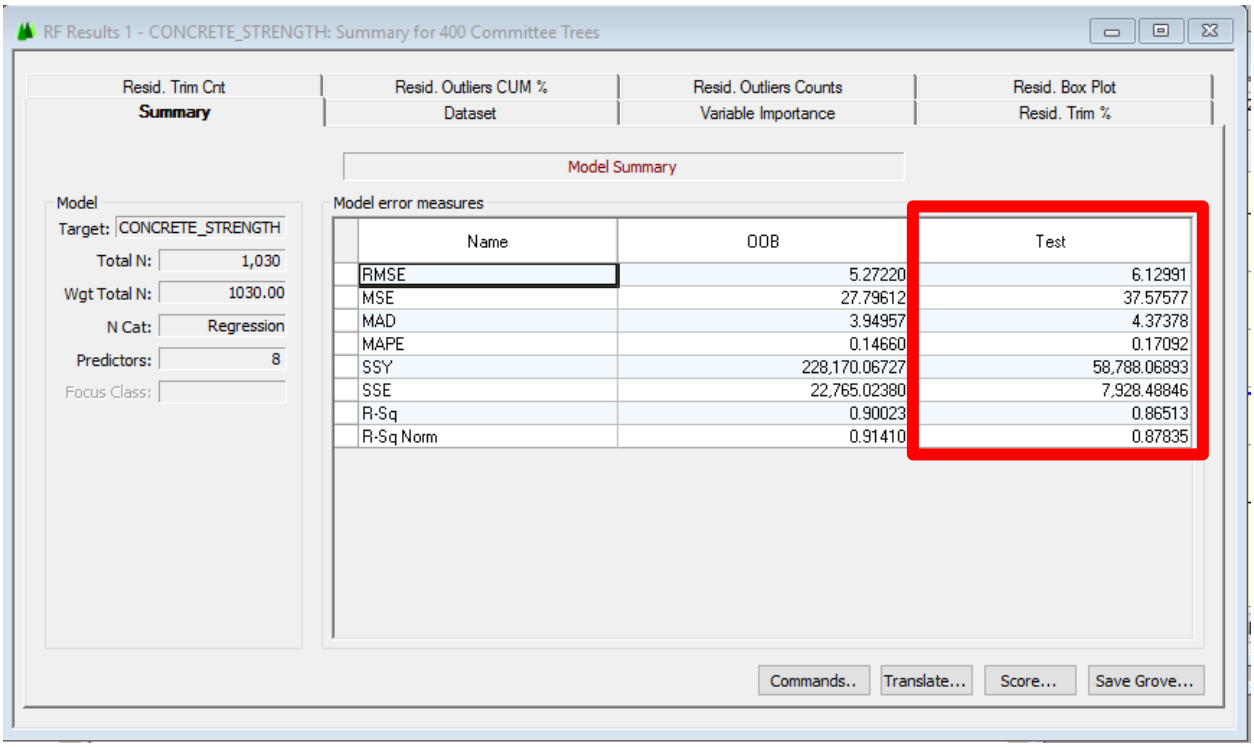
The result will be the following:



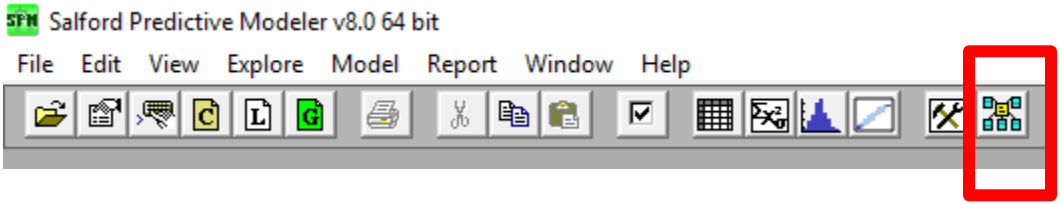
5. Now click “Summary” (red rectangle below) to view the results of the RandomForests. The model statistics that you see correspond to the optimal number of trees which in this case is 400



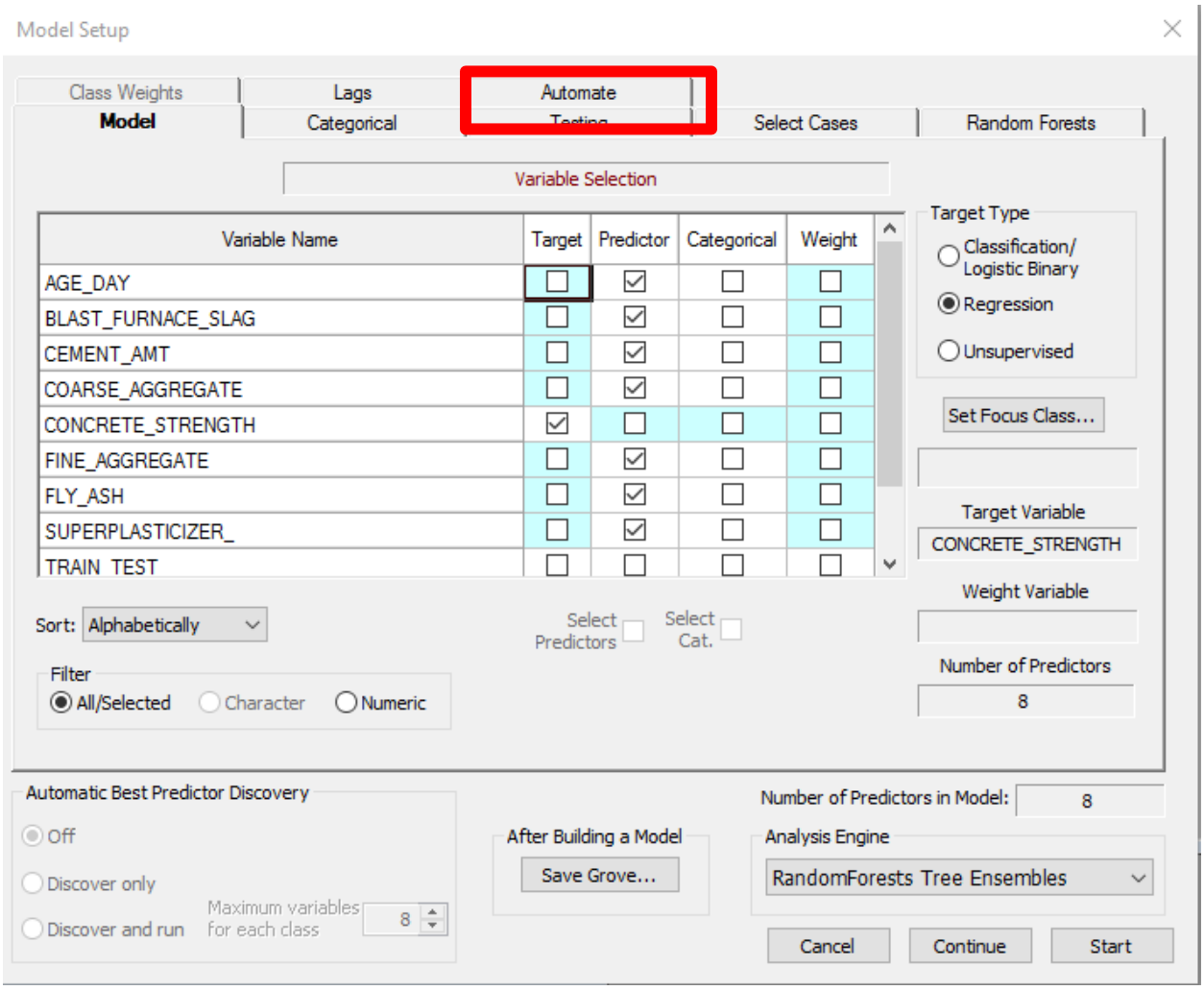
The results will be the following. Pay attention to the model statistics in the “Test” Column (red rectangle below):



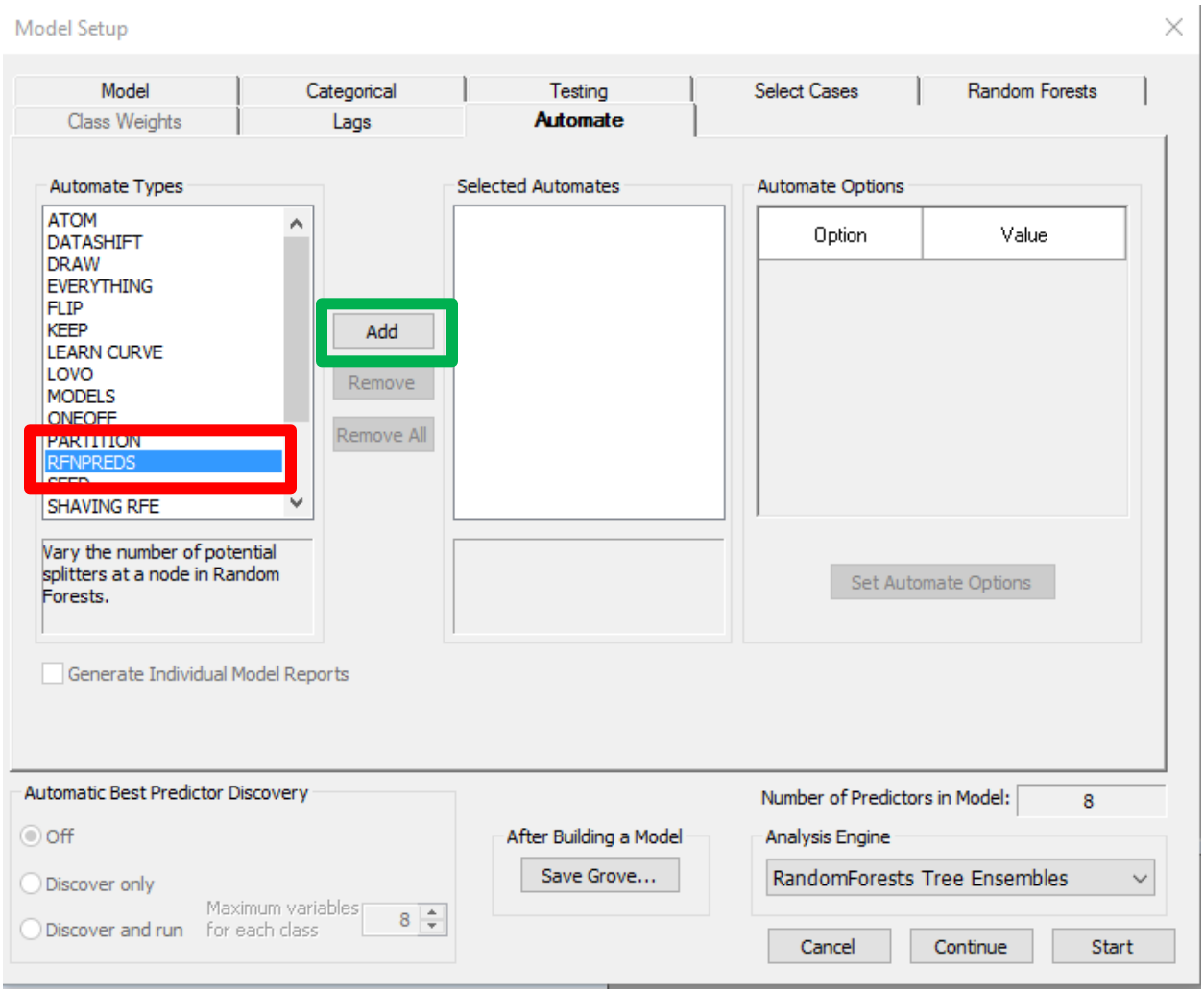
6. Now we are going to determine the optimal number of variables to randomly select at each split in CART tree in the Random Forest. Click the model setup button again to open up the Random Forest model interface:



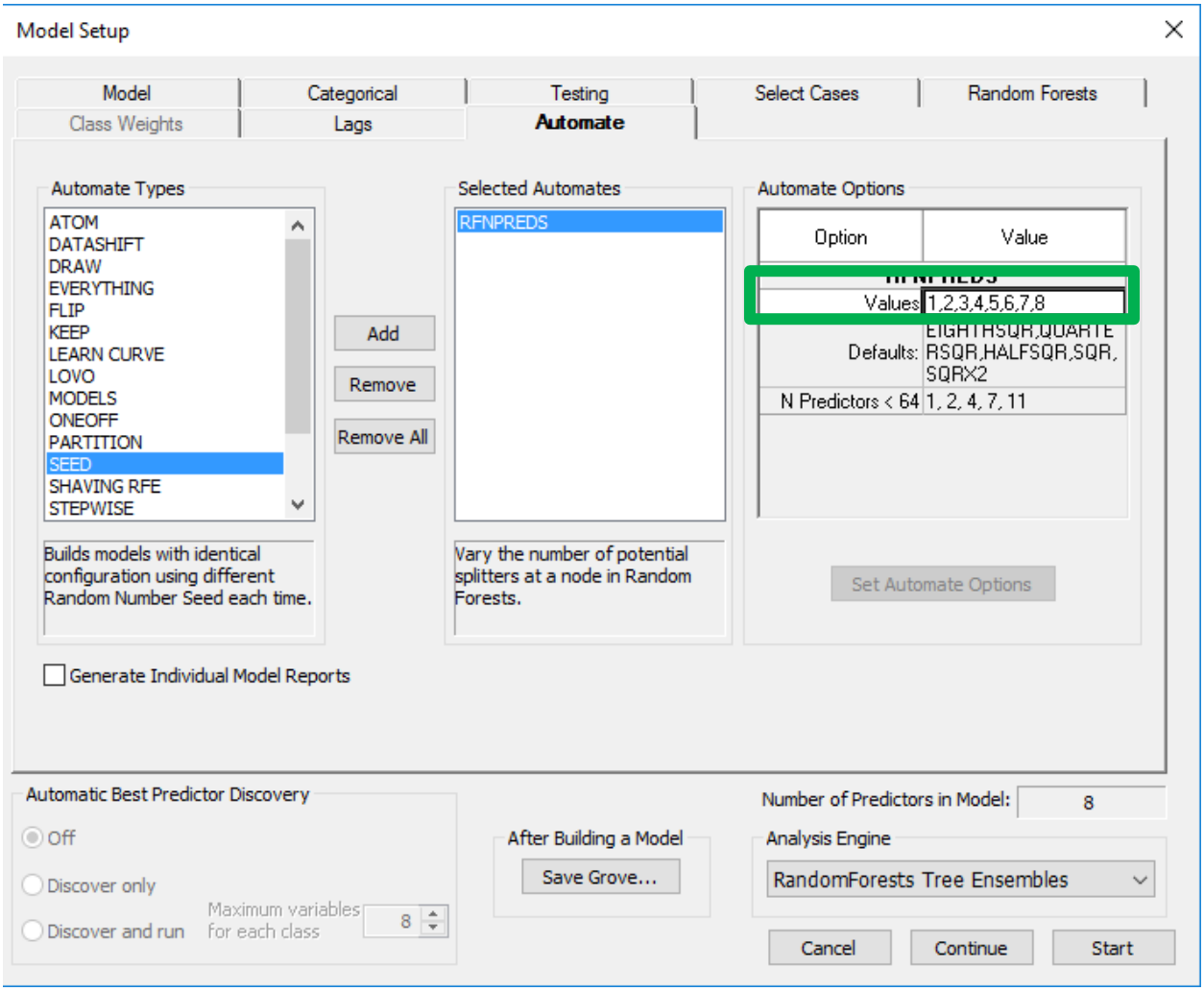
The result will be the following. Click “Automate” (red rectangle below)



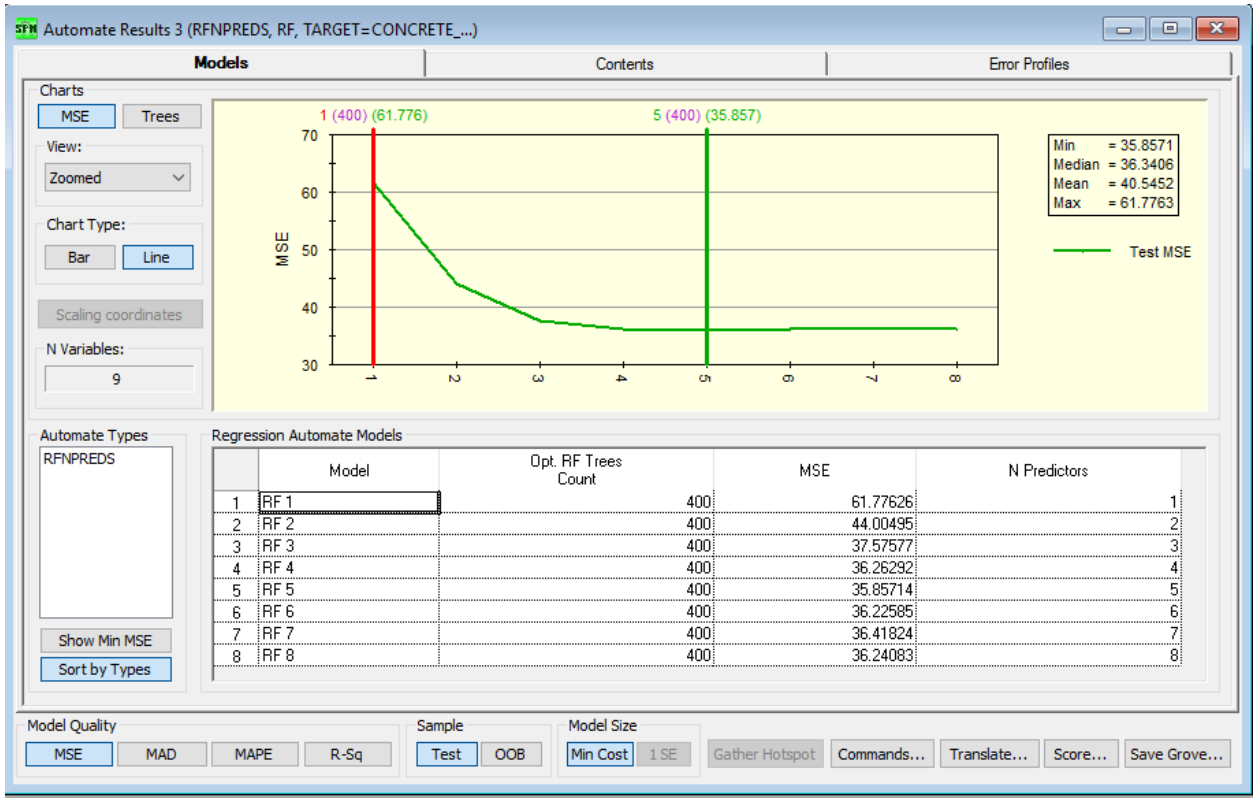
7. Click on “RFNPREDS” (red rectangle below) and then click “Add” (green rectangle below)



The result will be the following (Note: as a shortcut you can just double click “RFNPREDS”). Click into the box next to “Values” (green rectangle below) and type the numbers (with commas) 1,2,3,4,5,6,7,8. This will construct 8 Random Forests: the first is built by selecting one variable randomly at each split in each tree in the forest, the second is built by selecting two variables randomly at each split in each tree in the forest, and so on. Note: we select these variables randomly, determine the best split for each of these selected variables and then the final split is the variable and split combination that most reduces the model error.



The result of Automate RFNPREDS is the following:



The optimal number of variables to randomly choose at each split is 5. Note: you can view any of the 8 Random Forests that were just constructed by double clicking “RF1”, “RF2”, and so on. Here is what you will see if you double click “RF3”: it is the same as if you built this model by itself.